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Supporting Information

Silicon Nanowires Decorated with Gold Nanoparticles via *In-Situ* Reduction for Photoacoustic Imaging-guided Photothermal Cancer Therapy

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1. Calculation of the photothermal conversion efficiency

Following Roper's report, the total energy balance for the system can be expressed by Eq. 1:

$$\sum_{i} m_i \, C_{p,i} \frac{dT}{dt} = Q_{NC} + Q_{Dis} - Q_{Surr} \tag{1}$$

where m and C_p are the mass and heat capacity of water, respectively, T is the solution temperature, Q_{NC} is the energy inputted by NCs, Q_{Dis} is the baseline energy inputted by the sample cell, and Q_{Surr} is heat conduction away from the system surface by air.

The laser-induced source term, represents heat dissipated by electron-phonon relaxation of the plasmons on SiNWs-AuNPs surface under the irradiation of 1064 nm laser:

$$Q_{NC} = I(1 - 10^{-A_{1064}})\eta \tag{2}$$

where I is incident laser power, η is the conversion efficiency from incident laser energy to thermal energy, and A_{1064} is the absorbance of the SiNWs-AuNPs at wavelength of 1064 nm. In addition, source term, Q_{Dis}, expresses heat dissipated from light absorbed by the quartz sample cell itself, and it was measured independently to be 10.9 mW using a quartz cuvette cell containing pure water without a SiNWs-AuNPs. Furthermore, Q_{Surr} is linear with temperature for the outgoing thermal energy, as given by Eq. 3:

$$Q_{Surr} = hs(T - T_{Surr}) \tag{3}$$

where h is heat transfer coefficient, s is the surface area of the container, and T_{Surr} is ambient temperature of the surroundings.

Once the laser power is defined, the heat input (Q_{NC} + Q_{Dis}) will be finite. Since the heat output (Q_{Surr}) is increased along with the increase of the temperature according to the Eq. 3, the system temperature will rise to a maximum when the heat input is equal to heat output:

$$Q_{NC} + Q_{Dis} = Q_{Surr-Max} = hs(T_{Max} - T_{Surr}) \tag{4}$$

(4),

where the $Q_{Surr\text{-}Max}$ is heat conduction away from the system surface by air when the sample cell reaches the equilibrium temperature, and T_{max} is the equilibrium temperature. The 1064 nm laser heat conversion efficiency (η) can be determined by substituting Eq. 2 for Q_{NC} into Eq. 4 and rearranging to get

$$\eta = \frac{hs(T_{Max} - T_{Surr}) - Q_{Dis}}{I(1 - 10^{-A_{1064}})}$$

(5),

where Q_{Dis} was measured independently to be 10.9 mW, the (T_{max}-T_{Surr}) was 21.6 °C according to Figure 3g, I is 1.0 mW/cm^2, A_{1064} is the absorbance (0.46949) of SiNWs-AuNPs at 1064 nm (Figure S3a). Thus, only the hs remains unknown for calculating η. In order to get the hs, a dimensionless driving force temperature, θ is introduced using the maximum system temperature, T_{max}

$$\theta = \frac{T - T_{Surr}}{T_{Max} - T_{Surr}}$$

(6),

and a sample system time constant $\boldsymbol{\tau_s}$

$$\tau_s = \frac{\sum_i m_i C_{p,i}}{hs} \tag{7},$$

which is substituted into Eq. 1 and rearranged to yield

$$\frac{d\theta}{dt} = \frac{1}{\tau_s}\left[\frac{Q_{NC} + Q_{Dis}}{hs(T_{Max} - T_{Surr})} - \theta\right] \tag{8},$$

At the cooling stage of the aqueous dispersion of the SiNWs-AuNPs, the light source was shut off, the Q_{NC} +Q_{Dis} = 0, reducing the Eq. 9

$$dt = -\tau_s \frac{d\theta}{\theta} \tag{9},$$

and integrating, giving the expression

$$t = -\tau_s \ln\theta \tag{10},$$

Therefore, time constant for heat transfer from the system is determined to be $\boldsymbol{\tau_s}$ = 265.8 s by applying the linear time data from the cooling period (after 600 s) vs negative natural logarithm of driving force temperature (Figure 3h). In addition, the m is 0.5 g and the C is 4.2 J/g. Thus, according to Eq. 7, the hs is deduced to be 7.7 mW/ ºC. Substituting 7.7 mW/ ºC of the hs into Eq. 5, the 1064 nm laser heat conversion efficiency (η) of SiNWs-AuNPs can be calculated to be 24.1%. The calculation method of the photothermal conversion efficiency of pure SiNWs suspensions was similar to the one of SiNWs-AuNPs and the efficiency of pure SiNWs was 12.2% (Figure S4).

2. Supporting Figures

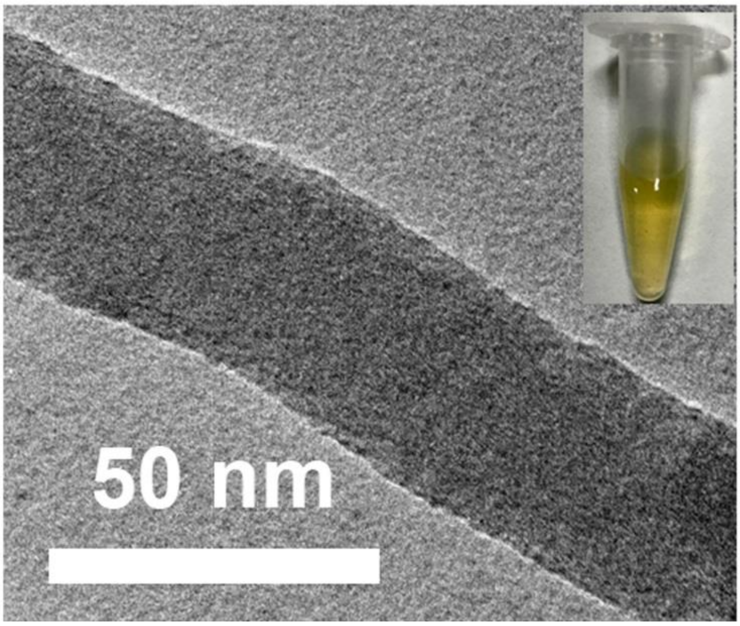

Figure S1. TEM image of a pristine SiNW, the insert image being the appearance of SiNW dispersion.

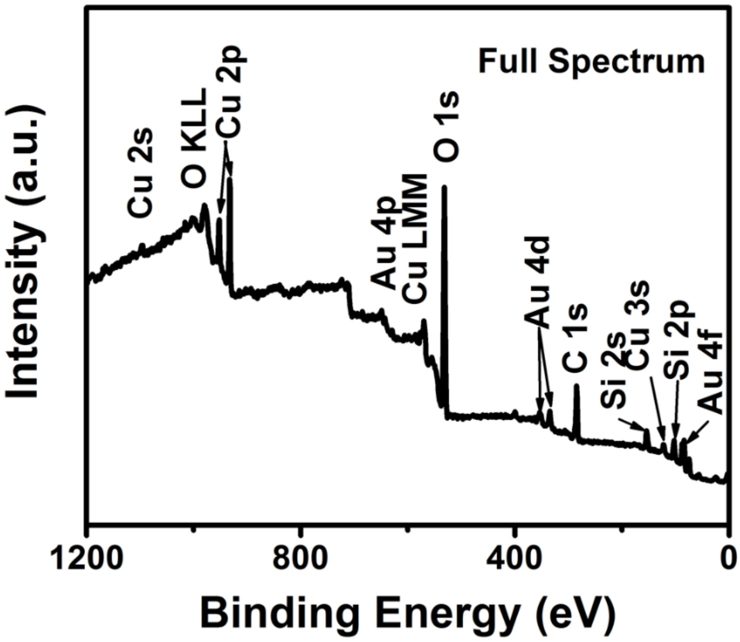

Figure S2. XPS full spectrum of SiNWs-AuNPs (copper sheets as substrates).

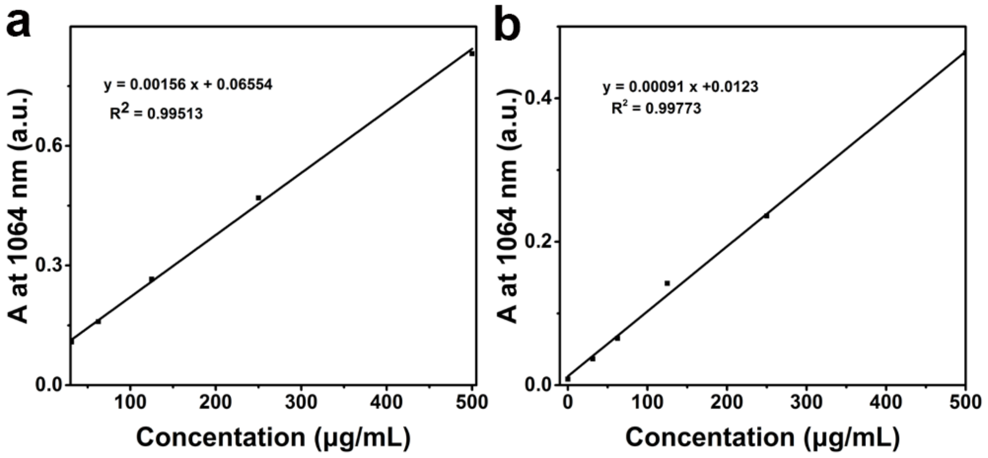

Figure S3. Normalized absorbance intensity with different concentrations at 1064 nm of (**a**) TA-SiNWs-AuNPs and (**b**) pure SiNWs suspensions (A means absorbance).

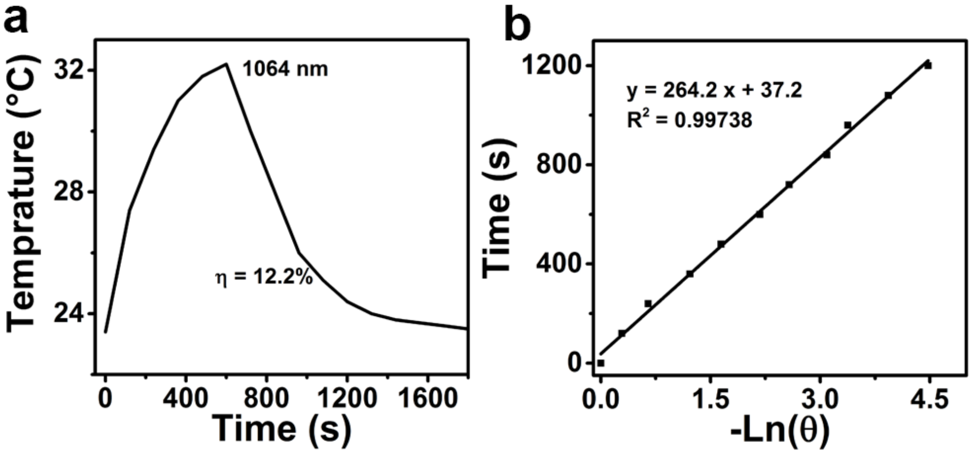

Figure S4. (**a**) Temperature profile of pure SiNWs suspensions (300 µg/mL) irradiated by 1064 nm laser (1.0 W/cm^2) for 10 min followed by natural cooling with the laser turned off; and (**b**) Measuring the time constant for heat transfer from the system using a linear regression of cooling profile.

Table S1. Photothermal performance of reported PTAs in the NIR-II region

PTAs	Con (μg/mL)	Power (W/cm^2)	Δ T (^{o}C)	PTCE	Refs
Ultrathin PPy Nanosheets	**100**	**1**	**40.2**	**64.6%**	**Nano Letters. 2018, 18, 2217**
PEGylated Cu_3BiS_3 Nanorods	**150**	**1**	**27**	**40.7%**	**Biomaterials. 2017, 112, 164.**
Au@$Cu_{2-x}S$ Nanocrystals	**200**	**0.7**	**20.5**	**43.3%**	**Adv. Mater. 2016, 28, 3094.**
Au-Cu_9S_5 Nanoparticles	**50**	**0.7**	**19.6**	**37%**	**J. Am. Chem. Soc. 2014, 136, 15684.**
Fe_3O_4@CuS-PEG Nanoparticles	**300**	**3**	**22**	**19.2%**	**Adv. Funct. Mater. 2015, 25, 6527.**
H-SiO_x-PEG Nanoparticles	**36**	**1**	**23.5**	**48.6%**	**Biomaterials. 2017, 143, 120.**
CoP-Nanocrystals	**200**	**0.8**	**29.1**	**21.2%**	**Small. 2017, 13, 1700798.**
Au Nanorod@PPy@Fe_xO Nanocomposites	**200**	**1**	**16.5**	**46.0%**	**Nano Research. 2016, 9, 787.**
Fe_3O_4 Nanoclusters	**375**	**0.38**	**24**	**20.8%**	**Nanoscale. 2015, 7, 12689.**
$(NH4)_xWO_3$ Nanocubes	**250**	**1.4**	**24.8**	**39.4%**	**Biomaterials. 2015. 02. 054**
SiNWs-AuNPs	**300**	**1**	**21.6**	**24.1%**	**This work**